

4/1/85 - 4/30/86

FINAL REPORT, NASA Grant NAG 5-502

H.S. Hudson

### 1. Introduction

The National Aeronautics and Space Administration, under Grant NAG5-502 "Analysis of Active-Region Time Scales in Solar Total Irradiance Variability," supported research at UCSD during the period April 1985 through April, 1986. This research centered on the physical interpretation of medium-timescale variability of the total solar irradiance from the ACRIM instrument on board the Solar Maximum Mission. The chief result of this analysis is Paper 1 of the attached publication list, entitled "Observation of Slow Variations in the Solar Luminosity." The paper has been accepted for publication in *The Astrophysical Journal*, and is presently undergoing final revision. Copies of this and other papers benefiting from support under this grant are attached to this report, and are listed in the bibliography below.

### 2. Scientific Background

The Active Cavity Radiometer Irradiance Monitor, or ACRIM, began observation in February 1980 under the guidance of R.C. Willson (JPL), its Principal Investigator. It was immediately obvious from the first few weeks of data that this "solar constant" measurement had succeeded for the first time in achieving an adequate sampling of total solar irradiance - both in precision and in time - so that true solar variability could easily be recognized on a variety of time scales. Since 1980, many analyses of different aspects of these data have been underway.

The most striking individual variation is that due to solar active regions, and specifically sunspots. The initial analyses of active-region effects were carried out in the "time domain," that is in characterizing the actual time series of ACRIM measurements and comparing it with time series taken from other sources, chiefly the solar synoptic data. These analyses continue to the present, taking advantage of the new long time series of solar-quiet data taken after the SMM repair mission of May 1984.

In the meanwhile it was clear that a frequency-domain analysis was needed. The power spectrum of solar luminosity variability is directly useful in comparison with the variations observed on other stars. Particularly important was the question of "rotational modulation," i.e. a characteristic variation that is often used to determine the rotation rate of a distant star. What did the solar variability spectrum look like in the "active region time scales" band? This band was defined operationally with the ACRIM data, and in fact contains the solar rotational frequency of 0.43  $\mu$ Hz.

### 3. Active-Region Time Scales

1

(NASA-CR-183434) ANALYSIS OF ACTIVE-REGION  
TIME SCALES IN SOLAR TOTAL IRRADIANCE  
VARIABILITY Progress Report, 1 Apr. 1985 -  
30 Apr. 1986 (California Univ.) 3 p

N89-71135

Unclas

00/92 0222723

Paper 1 contains power-spectrum and other kinds of analysis of ACRIM data from its beginning up through 1985, and is based upon the daily-average data prepared by Willson. Such sampling allows us to study time variability up to the associated Nyquist frequency of  $5.8 \mu\text{Hz}$ , well above the rotational frequency and (it turned out) interesting in terms of our ability to characterize the "active region time scales." This can be seen from Figure 7 of Paper 1, in which the excess power due to solar rotation and to the growth and decay of active regions is visible above a background spectrum. This latter continuum is probably due, based upon other analysis, to the solar surface granulation.

We also found from this analysis that the highest frequencies in the daily sampling also showed a clear variation with the level of solar activity, even at frequencies above those that could be due to solar rotation. At this point, it is clear that an analysis at higher sampling is necessary to understand the relationship between the active-region component and the granulation component of the power spectrum. This analysis will be possible from the extended data now available from SMM and from the re-reduction now under way (see the unpublished report listed as Paper 5 in the bibliography).

#### 4. Conclusions

Paper 1 is now in the process of revision for final publication. Its results will form an excellent platform upon which to base the more complete frequency-domain analysis from the longer time series now available (at time of writing, the repaired SMM is about to begin its fifth year of excellent data) and better sampling of the re-reduced data.

### Bibliography

1. Hudson, H.S., Gruber, D.E., Willson, R.C., and Woodard, M., "Observation of Slow Variations of Solar Luminosity," *Ap. J.*, to be published 1988 (UCSD SP-85-29).
2. Willson, R.C., Hudson, H.S., Frohlich, C., and Brusa, R.W., "Long-Term Downward Trend in Total Solar Irradiance", *American Assoc. for Advancement of Science*, 234, 1114-1117 (1986) (UCSD SP-85-31).
3. Hudson, H.S., "Energy Balance in Solar Active Regions: The Dip of April, 1985", *Adv. Space Res.*, 16, No. 8, 81-83, (1986) (UCSD SP-86-12).
4. Hudson, H.S., "Solar Variability and Oscillations", *Reviews of Geophysics*, 25, No. 3, 651-662 (1987) (UCSD SP-86-24).
5. Abraham, R., and Hudson, H., "Notes on ACRIM-I Re-reduction", (1987) (UCSD SP-87-03).